Experience from InSAR monitoring of transport infrastructure in the Czech Republic: Adaptation of InSAR results to the geodetic standards

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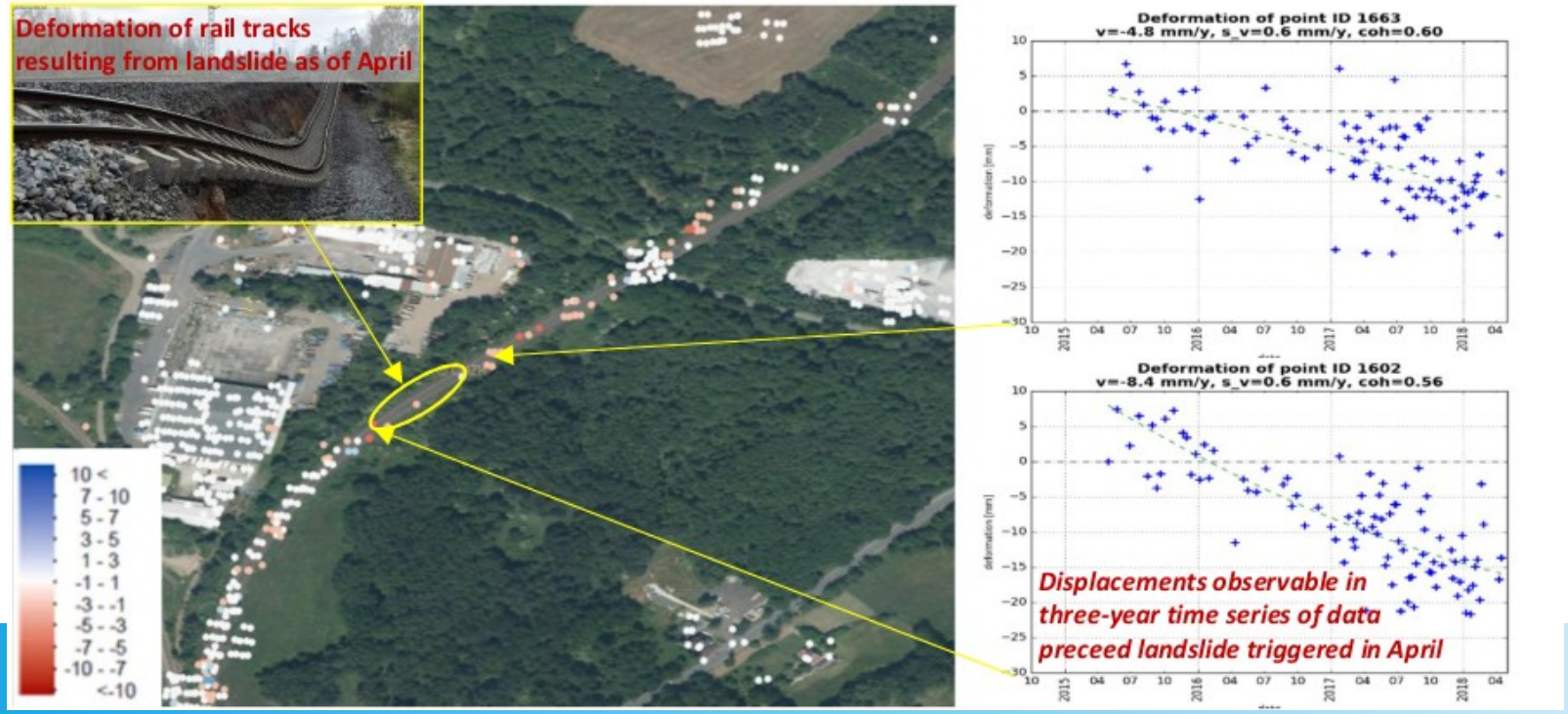
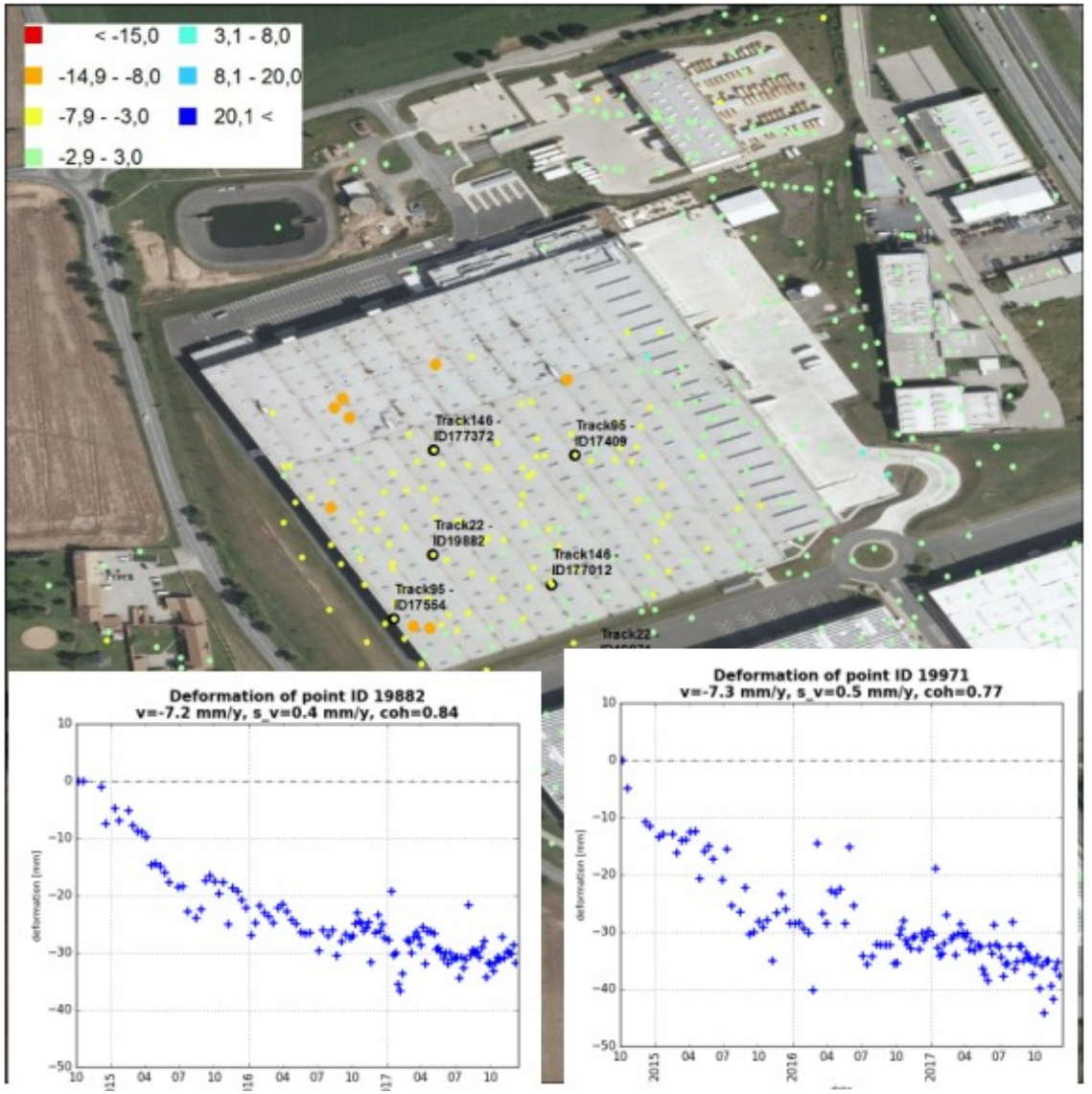
Motivation

- Sentinel-1 → extension of InSAR applicability
- Infrastructure monitoring R&D projects
- → interesting for state agencies (highway, railway, bridges)
- Results to be explained to geodesists



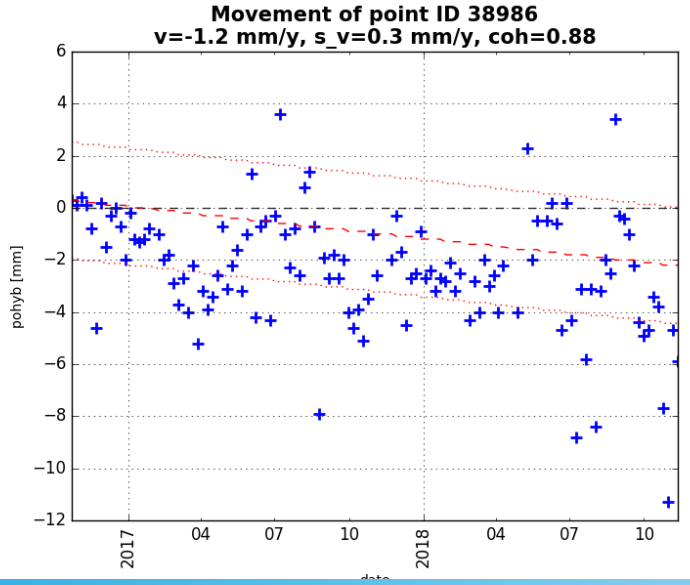
Comparison InSAR/geodesy

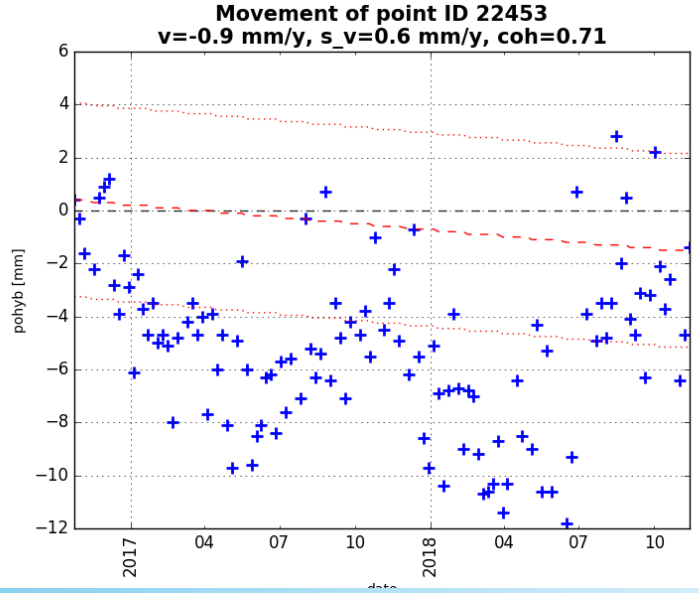
- Spatial + temporal coverage
- Monitoring to the past
- Uncertainty about the measured point locations
- Uncertain movement direction and cause
- Unclear accuracy
- Validation: no definition of velocity (low accuracy of measurements)



Geodesists' requirements

- Accuracy of the method / data
  - Different for local scale and long-distances
  - Depends on the quality of the reference point
  - CR as a reference point?
- Reference network → worse accuracy, higher reliability
  - possible spatial trends → detrending? accuracy?
  - Points?



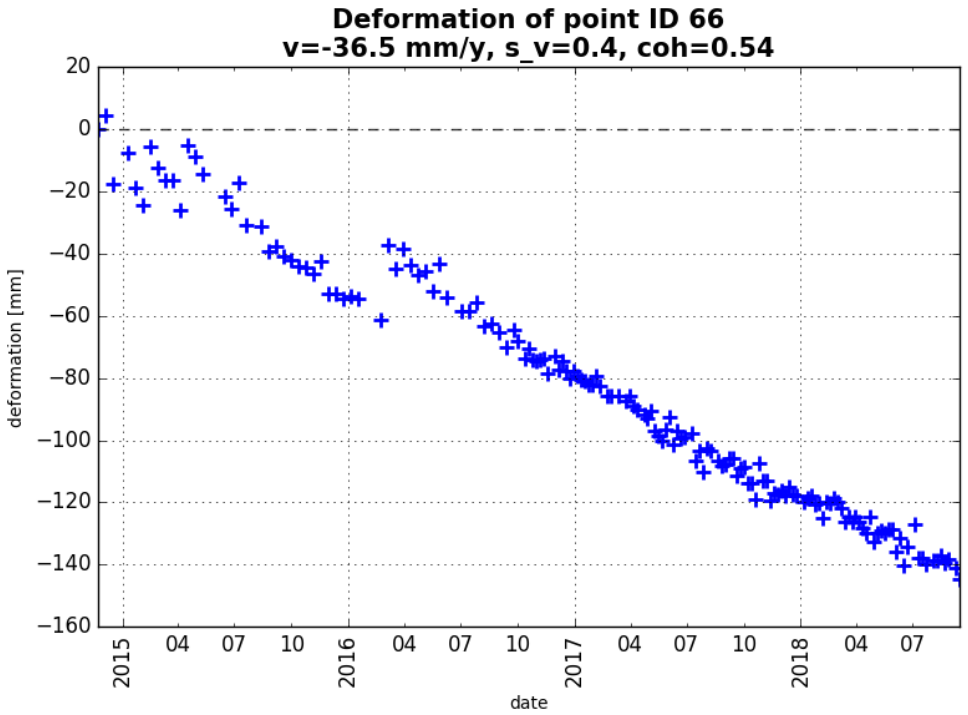


InSAR limitations

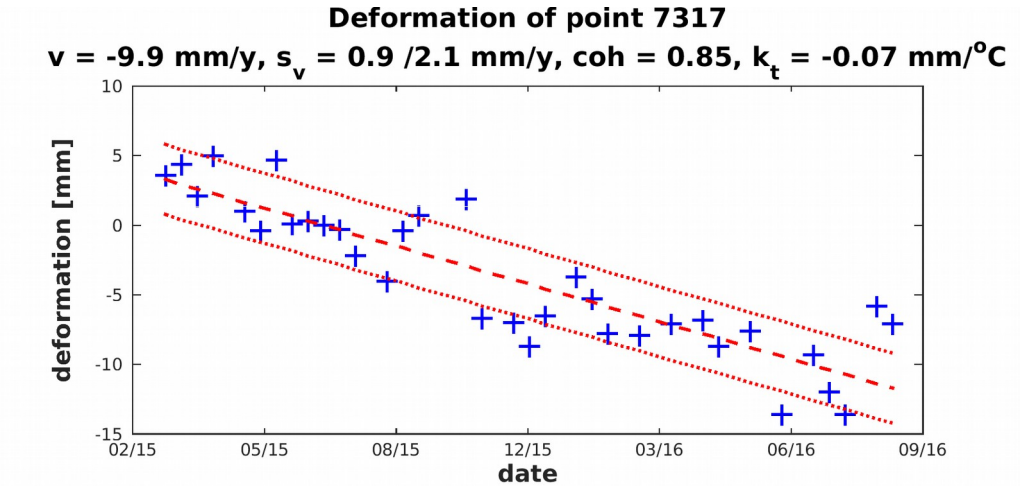
- Low point density in vegetated areas
- CR installation: size/coherence
- Using an apriori (linear) model
- Ambiguities → nonlinear system with possible systematic errors
- APS: estimation from the data, accuracy impact?

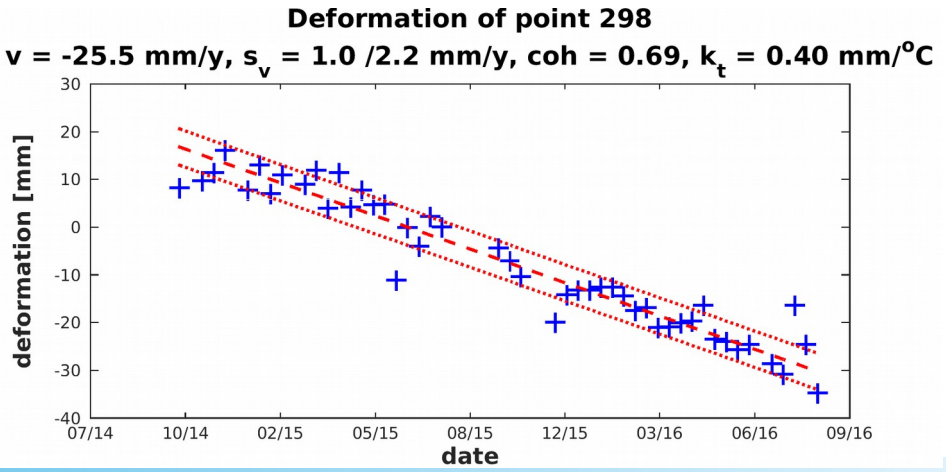
InSAR limitations: examples

Artifact: jump of appr. 28 mm estimated by InSAR, very improbable



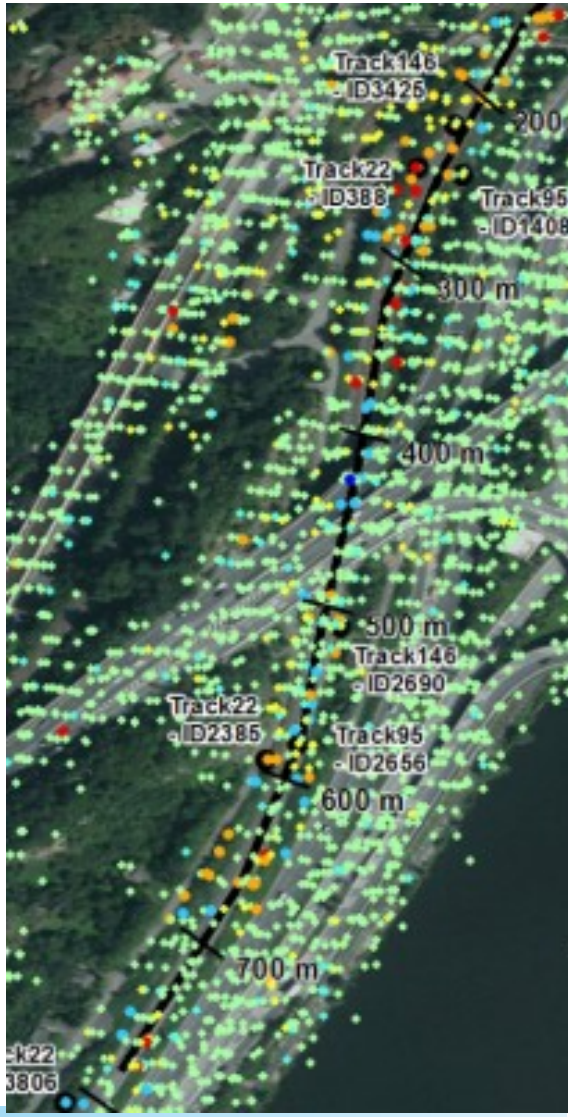
Real jump: bridge rectification (11/2015) 15 mm down (LOS 12 mm)





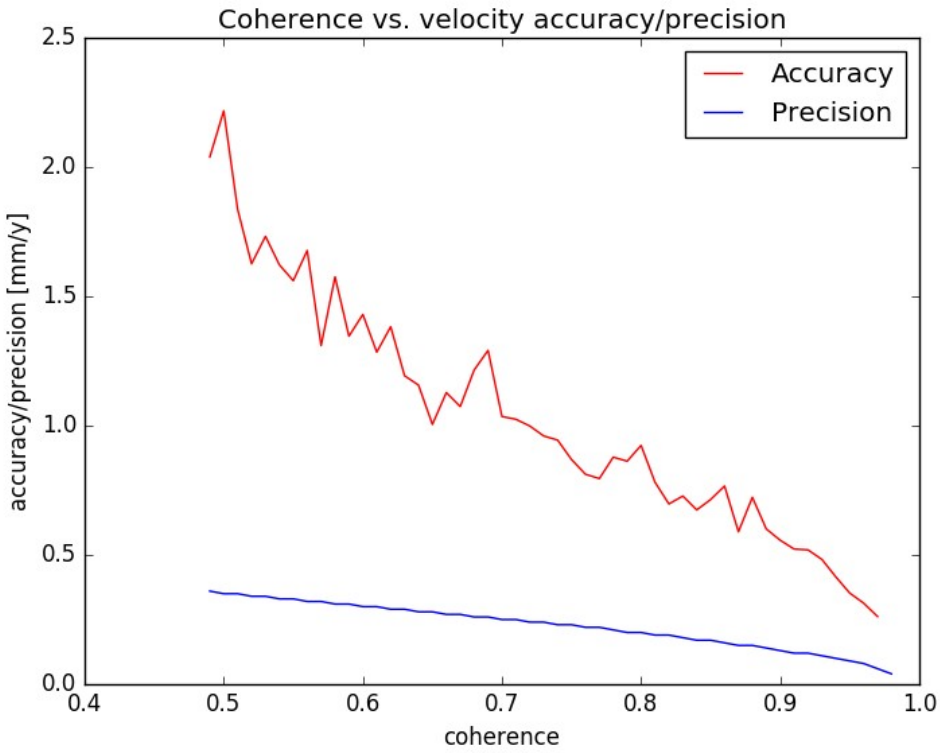
Coherence – precision - accuracy

- Coherence: quality of the point (influenced by data)
  - Measure of a fit to the apriori model
  - Independent of number of images and number of unknowns!
  - Does not say if the point moves or not
- Precision: repeatability of the measurement
  - Evaluated from coherence [Colesanti03] → still a property of the reflection cell
  - One-measurement stddev quite high
  - Velocity stddev low for high no. of images
- Accuracy: correspondence to the reality
  - APS influence should be included



Accuracy estimation

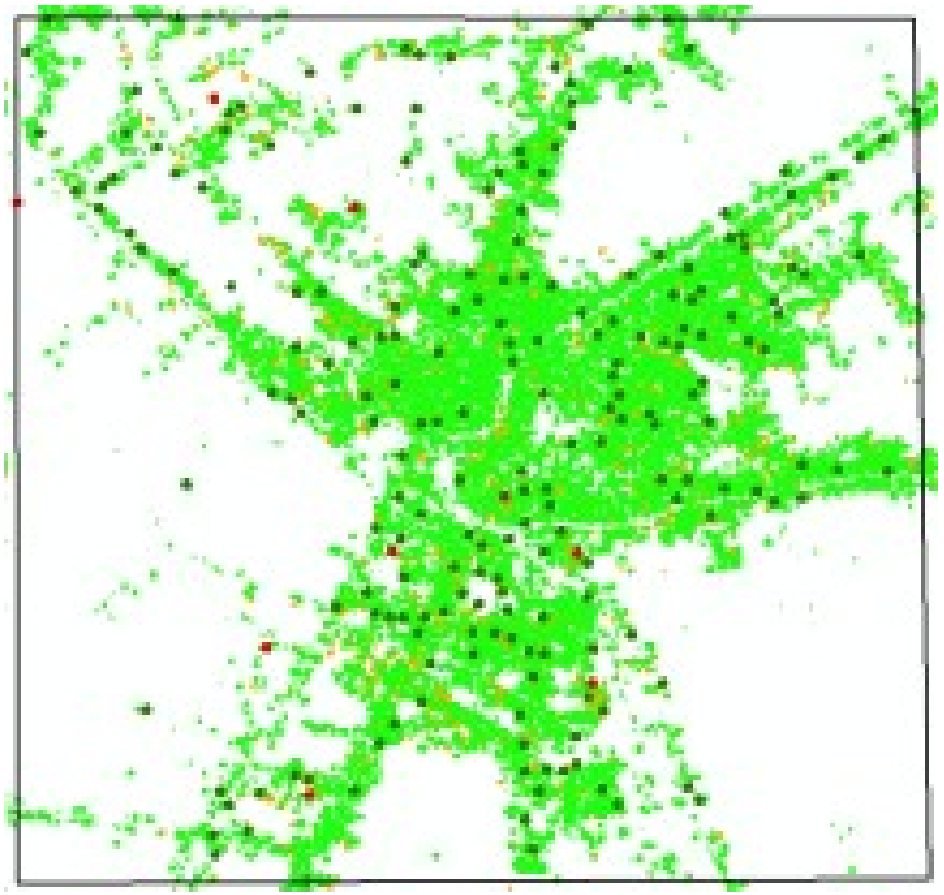
- Goal: to provide clients with a “credible” estimation of accuracy
- Processing performed on a **stable** area, same dataset, >= 5000 points
- Points divided into groups according to their coherence
- Velocity mean/stddev calculated
- Outliers excluded



Large areas: accuracy after swath merge?

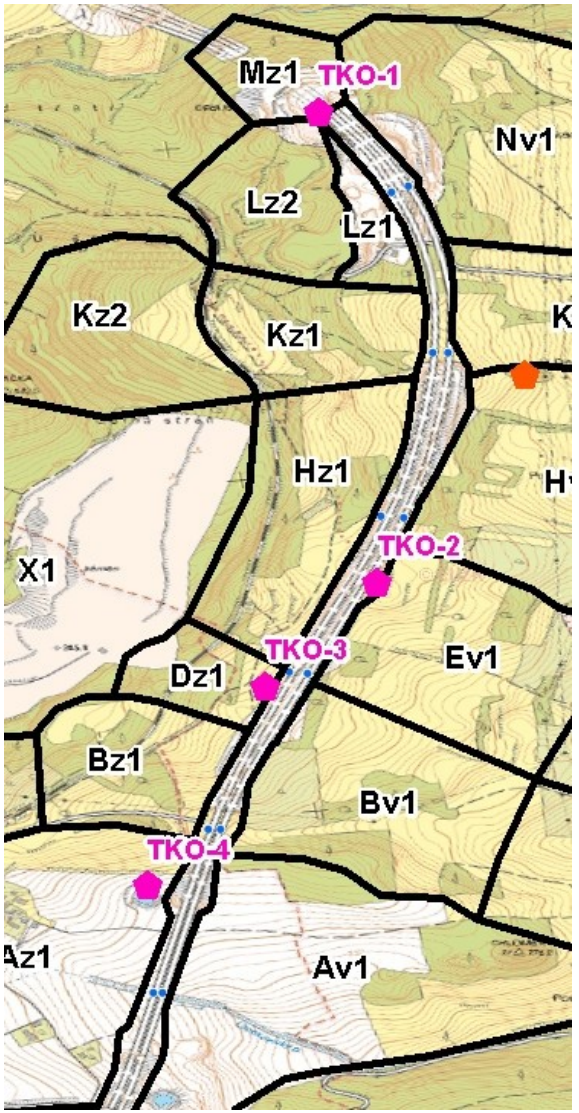
Validation

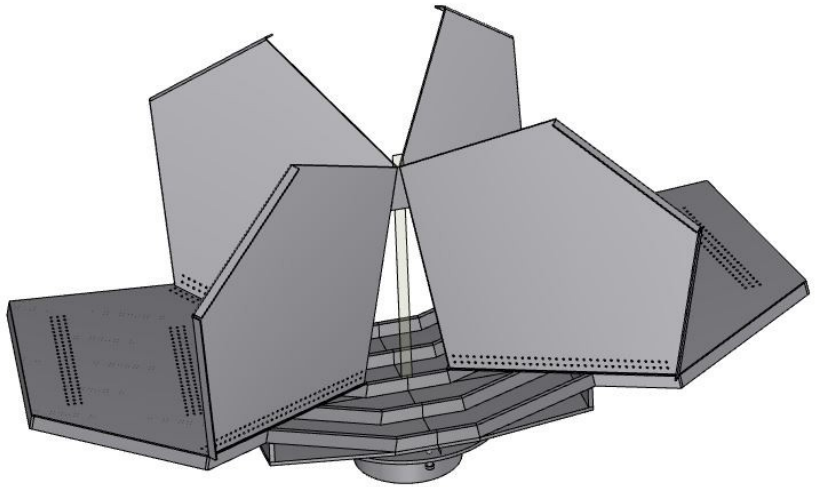
- Ground-based validation only on few points (global scale? trends?)
- Temporal interpolation: based on the (linear) model, or interpolation?
- Necessity to calculate thermal dilations between the two points (possible illumination effects, temperature lags)
- Cross-track InSAR validation (movement direction!)



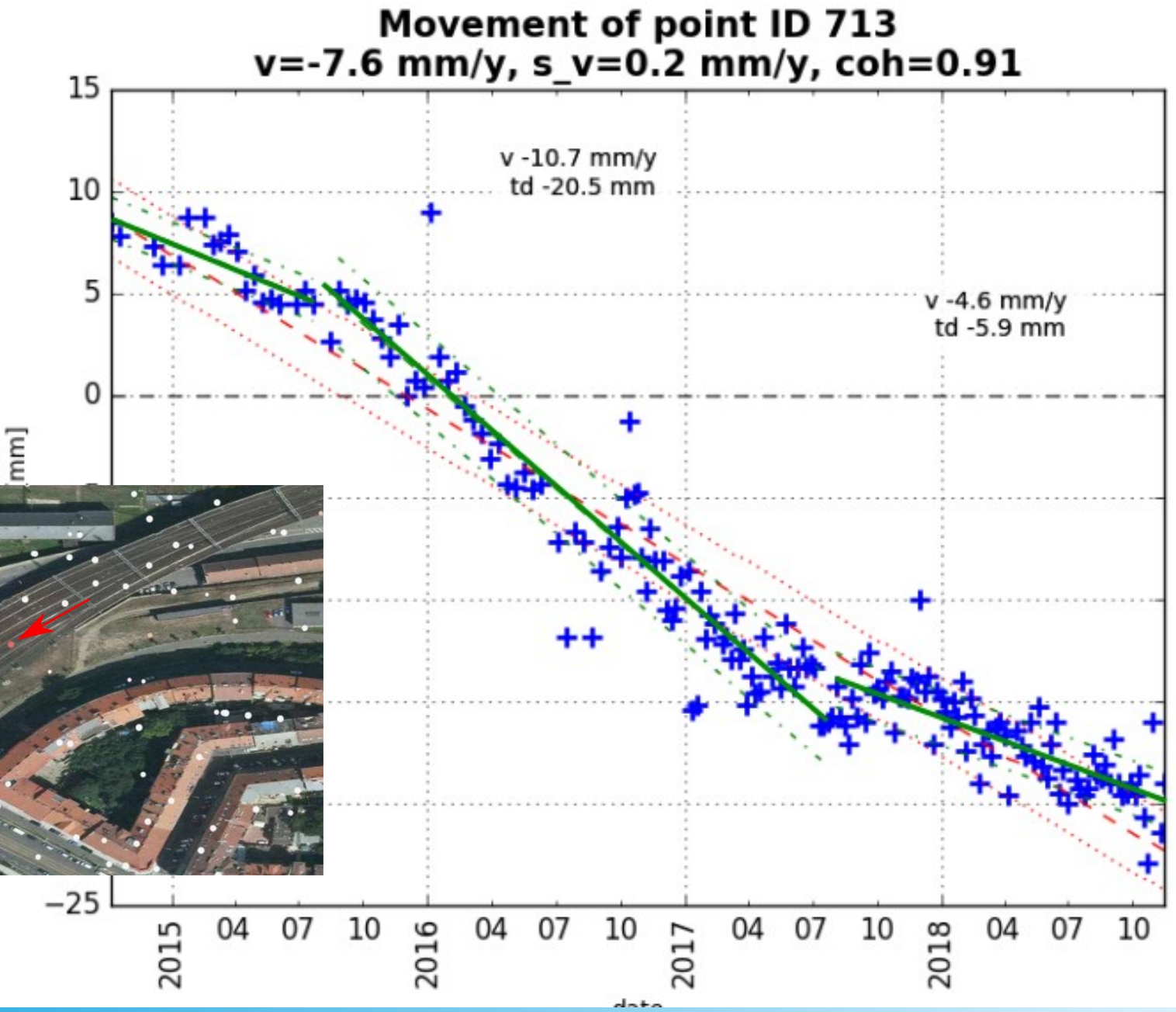
Designed method

- Monitoring of a highway built in a landslide-prone area
- Reference network: 4 both-sided CRs close the AOI, with possible “natural” points further away
- Points in the network periodically tested w.r.t. each other for possible movement
- GPS measurements on the CRs once a year, or in case of an “alarm” detected by InSAR (as a part of a GPS network)
- InSAR processing
- every 2 months





Future: automatic TS classification



Thank you!

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Shenzen algorithm

- TS re-reference to all points (reliability!)
- Results less dependent on the quality (and location) of the ref. point
- Colesanti's relation between coherence and precision distorted
- Residues stddev not really affected by Shenzen
- Stddev more sensitive to outliers, image exclusion necessary (coh remains similar!)
- → stddev as a quality of the measurement?
- → shall we apply Shenzen for geodetic applications?